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Indian Standard

TEST CODE FOR GRAIN DRYERS

PART 3 METHODS OF TESTS FOR IN-SILO DRYERS

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TEST CODE FOR GRAIN DRYERS

PART 3 METHODS OF TESTS FOR IN-SILO DRYERS

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TEST CODE FOR GRAIN DRYERS

PART 3 METHODS OF TESTS FOR IN-SILO DRYERS

0. FOREWORD

0.1 This Indian Standard (Part 3) was adopted by the Indian Standards Institution on 28 February 1985, after the draft finalized by the Agricultural Produce Processing Equipment Sectional Committee had been approved by the Agricultural and Food Products Division Council.

0.2 It is well known that if the crop having low moisture content is harvested, the shattering loss is more and if it is harvested at high moisture content, the storability and quality of the grain is very much reduced. In order to have a compromise between these two extreme situations, it is desirable to harvest the crop at a comparatively high moisture content and dry the grain to the required moisture content suitable for its storage and quality maintenanee. Drying may be done in sun or by mechanical process. Sun drying is time consuming and a non-uniform process, Moreover, in some grains such as paddy, the quality of the grain is reduced if it is dried in the sun. It is, therefore, advisable to employ mechanical dryers. This would ensure the increased manufacture and use of the grain dryers by processing industry in the country.

0.3 Although the function of a grain dryer is to remove excess moisture from grain without loss of quality, the evaluation of its performance is very complex due to a wide variety of designs and sizes to cover the diverse requirements for drying capacity and cost. This code is, therefore, being issued to provide a procedure for evaluating the performance of the dryers which should be of practical use to both the users and the manufacturers.

0.4 This standard is being published in three parts. This part (Part 3) covers methods of tests for in-silo dryers. Other parts of the standard are as under:

Part 1 Selection and preparation for test.

Part 2 Methods of tests for continuous dryers.

0.4.1 The committee felt the need for stipulating the method for taking the samples of grain, number of samples and depth of which the samples are to be taken in a vertical plane in a silo. In view of non-availability of the information, it was decided to be incorporated at a later date.

0.5 In preparation of this standard, considerable assistance has been taken from M/s S. F. India Ltd, Calcutta, besides deriving assistance from the following:

BS 3986 : 1966 Methods of test for agricultural grain driers. British Standards Institution.

ASAE S 248 : 2-1976 Construction and rating of equipment for drying farm crops. American Society of Agricultural Engineers, USA.

0.6 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

1. SCOPE

1.1 This standard (Part 3) prescribes the method of testing for in-silo dryers to evaluate their performance.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 8420-1977† shall be followed.

3. GENERAL

3.1 Drying silos are normally made for drying, cooling, aeration and storing. In a ventilated storage, the following effects may usually be obtained:

a) A very slow drying of the air has a certain drying potential with regard to the condition of the stored grain,
b) An equalizing effect on the temperature in the silo,
c) Removing heat formed by respiration and cooling of the grains in the silo provided the air is reasonably cold, and
d) A conserving effect in addition to the above.

3.2 Normal (cereals) and slow drying (peas, beans, etc) grains with too high a moisture content can be dried by continuous ventilation to a level of moisture content which is in equilibrium with ambient air. Of course, the relative humidity can be lowered by slightly heating the air by about 5°C and consequently a lower final moisture content. There should be enough air to dry the batch within a given time so as to maintain the quality of the grains. The degree of supplementary heating should not generally exceed 7°C.

*Rules for rounding off numerical values (*revised*).
†Glossary of terms relating to grain dryers.

3.3 For practical reasons, the moisture extraction from ventilated silos is limited to about 3 percent in almost all the cases and in other words to the following moisture extraction depending on the final moisture content:

a) 20 to 17 percent

b) 19 to 16 percent

c) 18 to 15 percent

d) 17 to 14 percent

3.4 The grain should be ventilated until the entire batch reaches the required final moisture content. This process should be terminated within a definite period. If the moisture content is 19 to 20 percent before drying two weeks is recommended; for lower moisture content 3 weeks is tolerable. For reasons of economy in the energy consumption, it is obvious that layer thickness should be limited according to the air quantities (hence to moisture extraction) and resistance of the grain to air flow.

3.5 Usually grain depth (Fig. 1) is limited to approximately 5 m and the moisture content to about 20 percent depending upon the type of grain, air temperature and relative humidity.

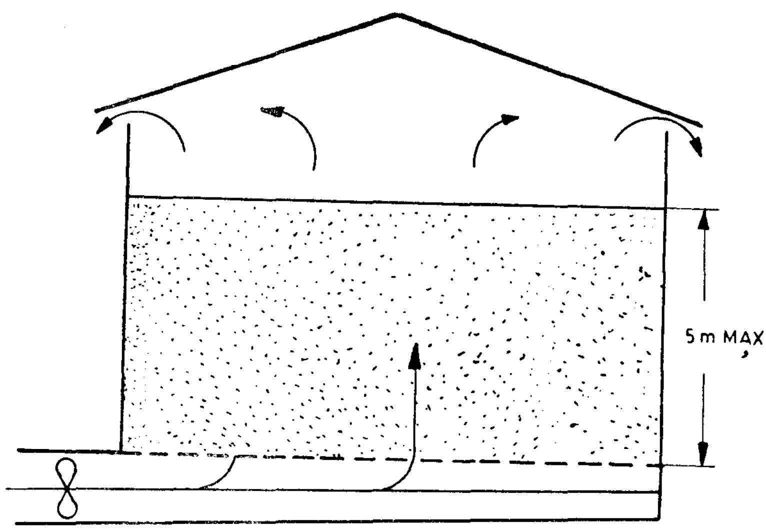

FIG. 1 DRYING IN A LARGE CELL

3.6 Drying in a silo is also possible where a suitable varying quantity is put-in, dried and then transported to storage, alternatively cooling or tempering. Such a large silo should be provided with some sort

of mechanical loading and unloading arrangement in order to obtain a rational operation when large batches are to be dried. Relatively high temperatures of up to 70°C are sometimes applied. Parboiled paddy is normally dried in two steps with tempering between drying intervals.

4. PREPARATION FOR TEST AND GENERAL TEST PROCEDURE

4.1 For the purpose of conducting the tests in the dryer the general procedures laid down in IS : 8108 (Part 1)-1984* shall be followed.

5. METHODOLOGY

5.1 In order to assess the performance of an in-silo dryer, installation details of the drying of grain in a typical silo shall be recorded. The total mass and moisture content of grain entering and leaving the silo, and the air flow to the silo at all times during the test shall be ascertained. The typical silo of grain shall be dried while the total number of silos being ventilated is not less than half the number designed to be ventilated at any one time. The grain dried in the typical silo shall be damp wheat as harvested, precautions being taken to avoid the use of grain which is immature. The grain shall have a moisture content as near as possible to 20 percent and no grain shall be admitted which has below 19 percent moisture content. The drying shall be continued until the mean moisture content of 14 to 15 percent has been obtained. The assumption shall be made on the time required to dry batches of 20 percent to a final moisture content of 17 percent, 16 percent, 15 percent and 14 percent under specified ambient conditions when all the silos and half the silos are being ventilated. Optional additional tests may be carried out when required by the manufacturer using the general procedure specified but with initial moisture contents other than 20 percent or with types of grain or seeds other than wheat.

5.2 For weighing the grains used in an in-silo dryer, following types of weighing machines are suitable:

a) The automatic or semi-automatic type in which batches are weighed continuously, and

b) The platform type on which the grain is weighed in sacks. The time of filling of each sack shall be recorded throughout the tests.

5.2.1 A weigh-bridge or other equipment designed to weigh similar quantities in one weighing operation may also be used. It is desirable

*Test code for grain dryers: Part 1 Selection and preparation for test (*first revision*).

that the same machine be used to weigh both the input and output grain. The maximum permittable weighing error shall be 0·2 percent of the net mass of the grain.

6. ORDER OF TEST

6.1 When a sufficient number of silos are being ventilated or are available for ventilation, the typical silo shall be filled with a measured mass of freshly harvested grain at the required moisture content and of reasonable purity (foreign matter and other crop seeds not exceeding 5 percent).

6.2 During filling, or after filling and if necessary levelling the grain, sufficient samples shall be taken to indicate the pattern of the moisture content throughout the bulk and to determine the mean value. Ventilation shall then be started and continued on a system agreed between the manufacturer and the testing authority, until the required mean moisture content reduction has been achieved, the measure of this for control purposes, being by means of samples drawn periodically from the bulk. The air flow to the silo under test shall be measured by using a standard procedure/device which has been calibrated and the error is not less than 5 percent. Alternatively the methods of measuring air flow given in **6.2** may be followed.

6.2.1 A cylindrical measuring duct shall be fitted to the fan and heater unit of the dryer only at times when measurements are to be carried out. All the dimensions of the measuring duct and the method of computing the air flow rates have been provided in IS : 4894-1968*. In those dryers where axial flow fans are used, the measurement of air flows shall be carried out in accordance with IS : 3588-1966†.

7. LOADING AND UNLOADING OF SILO

7.1 Loading and unloading of the silo shall be carried out in accordance with the manufacturers' published instructions but should additional levelling of the grain be required to improve the accuracy of the test, this shall be done at the request of the testing authorities, care being taken to avoid compaction of the grain.

7.2 For drying grains like rice, which is very sensitive and cracks easily, a multi-stage drying with tempering at an appropriate intervals during the drying is necessary. The loading, unloading and tempering time should be maintained in accordance with the published instructions of the manufacturer when the dryer is tested for such grain or seed.

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*Specification for centrifugal fans.

†Specification for electric axial flow fans.

8. CONTROL OF DRYING AIR CONDITION

8.1 Control of the condition of the air used for drying shall be a system agreed to between the manufacturer and the testing authority.

8.2 In certain cases manufacturer may recommend heating of the ambient air in order to dry certain seeds to 14, 15, 16 and 17 percent moisture content (wet basis) during ventilated storage. In such cases, the manufacturer should provide a set of curves showing the extent of rise in temperature of the ambient air required to reach the given moisture content of the seeds being dried. For example, with ambient air having a relative humidity of 80 percent, the air should be heated to over 2°C to dry cereals to 15 percent, or 1·5°C to dry peas to 16 percent moisture content.

8.3 With in-silo dryers for which the drying air may be conditioned to a relative humidity to the order of 60 percent, a large variation in the ratio of the evaporative capacity already existing in the ambient air to that which shall be created by artificial means may be obtained. Consequently, throughout the test of an in-silo dryer particular attention should be given to the degree of accuracy with which air temperature and humidities are determined.

9. MEASUREMENT AND CALCULATION OF RESULTS

9.1 The temperature of the air used for drying shall be recorded throughout the test preferably on a continuous temperature recorder. Recordings or repeated readings of other temperatures affecting the performance, including in particular, the air intake and exhaust and wet and dry bulb temperatures, shall also be made throughout the test. The temperature of the grain shall be measured before and after drying. The minimum number of samples taken before drying to determine the mean initial moisture content and germination capacity as well as after drying to determine the mean final miosture content and germination capacity shall be the same and in accordance with the following table:

Silo Capacity tonnes	*No. of Samples for Moisture Content*	*No. of Samples for Germination Capacity*
Less than 10	50	10
10 to 30	80	16
More than 30	100	20

9.2 The measure of drying shall be based on the mass of the batch of grain in a typical silo after drying, the mean moisture content of the grain at the time of filling the silo and the mean moisture content of the grain discharged from the silo. Appropriate methods of sampling and methods

of measurement of moisture content and other values are given in IS : 8108 (Part 1)-1984*. There may be circumstances when the mean output moisture content after drying could be accurately measured by the difference in mass of the grains in the silo before and after drying. When this procedure has been adopted the same shall be mentioned in the report.

10. PRESENTATION OF RESULTS

10.1 The results of the test shall be presented in Table 1 (*see also* Appendix A). The performance summary shall be calculated on the basis of test data and presented in the form of Table 2 (*see also* Appendix B).

NOTE — The results of the test presented in Table 1 where all the figures given for fluctuating quantities should be mean values for individual runs.

10.2 General Remarks — The following informations shall also be given.

10.2.1 A list of repairs and modifications to the dryer made during the test.

10.2.2 Any comments on particular features of the dryer or its behaviour which might adversely or otherwise affect its practical performance, its safety in operation and the working conditions of the operator with particular emphasis on noise and dust. The comments on the evenness of drying shall also be included.

10.2.3 Information on points of practical importance obtained from actual users of similar dryers shall be included in the report where appropriate.

10.2.4 A note on any features of the dryer installation which might have any affect on the dryer's performance.

10.2.5 The date of the test and the location of the site at which it was carried out.

*Test code for grain dryers: Part 1 Selection and preparation for test (*first revision*).

TABLE 1 SPECIMEN TEST REPORT FOR IN-SILO DRYER

(*Clause* 10.1)

i) Ambient conditions:	
a) Ambient temperature	°C
b) Ambient relative humidity	Percent
c) Barometric pressure	kPa
ii) Grain:	
a) Moisture content of input grain	Percent
b) Moisture content of output grain	Percent
c) Mass of we: grain	kg
d) Mass of dried grain	kg
e) Germination of wet grain	Percent
f) Germination of dried grain	Percent
g) Depression of germination	Percent
h) Temperature of wet grain	°C
j) Temperature of dried grain	°C
k) Depth or thickness of grain bed (initial)	m
m) Depth or thickness of grain bed (final)	m
iii) Drier temperature, drying time, air supply, fuel consumption and evaporation:	
a) Drying air temperature	°C
b) Drying air relative humidity	Percent
c) Exhaust air relative humidity	Percent
d) Drying time	h
e) Air supply	kg
f) Static pressure	kPa
g) Fuel consumption	l/h*
h) Power consumption	kWh
j) Evaporation	kg
iv) Results adjusted to specified ambient conditions†:	
a) Relative humidity	Percent
b) Air supply	kg
c) Static pressure	kPa
d) Fuel consumption‡	l/h*
e) Power consumption‡	kWh
f) Drying time	h
g) Specific evaporation§	kg/kWh
h) Specific energy consumption§	kj/kg

*Unit appropriate to the fuel used should be given.

†*See* Appendix A.

‡The fuel consumption and power consumption attributed to the typical silo should be the same proportion of the total fuel consumption and power consumption as the air quantity supplied to the typical silo is of the total air supply.

§The heat equivalents of the corrected fuel and power consumptions have to be taken into account.

TABLE 2 SPECIMEN FOR PERFORMANCE SUMMARY

(Performance of plant under specified ambient conditions estimated from measurements of air flow and evaporation made during the test of a typical silo.)

Relative Humidity, Percent	Mean Final Moisture Content, Percent	No. of Silos Ventilated	Initial Mass of Grain, *t*	Time to Dry from 20 Percent, *h*	Energy Required per Tonnes of Dried Grain		
					For Air Heating kWh	For Fan Power, kWh	Heat Equivalent of Total, MJ
75	17						
75	16						
75	15						
75	14						
75	17						
75	16						
75	15						
75	14						
80	17						
80	16						
80	15						
80	14						
80	17						
80	16						
80	15						
80	14						

APPENDIX A

(*Clause* 10.1; and *Table* 1)

CORRECTION TO RESULTS FOR TYPICAL IN-SILO DRYERS

A-1. Drying time to final moisture content shown in Table 1, from 20 percent initial moisture content should be calculated from the following formula:

$$Q_c = Q_t \frac{E_t}{E_c} \times \frac{(100 - p_t)(20 - q_t)}{80(p_t - q_t)}$$

where

Q_c = corrected drying time, h;

Q_t = drying time on test, h;

P_t = mean moisture content of wet grain on test, percent;

q_t = mean moisture content of dried grain on test, percent;

E_t = mean evaporation rate on test (that is, total evaporation on test $\div$ Q_t), kg/h; and

E_c = corrected mean evaporation rate, calculated as follows:

$$E_c = E_t \times \frac{g_{ce} - g_{ca}}{g_{te} - g_{ta}} \times \frac{D_c}{D_t} \text{ kg/h}$$

where

g_{ce} = exhaust absolute humidity at specified conditions, kg/kg dry air;

g_{ca} = ambient absolute humidity at specified conditions, kg/kg dry air;

g_{te} = exhaust absolute humidity during of period test when humidity is substantially constant, kg/kg dry air;

g_{ta} = ambient absolute humidity during period of test when exhaust humidity is substantially constant, kg/kg dry air;

D_c = density of air at main fan corresponding to specified ambient conditions, kg/m³; and

D_t = density of air at main fan on test, kg/m³.

g_{ce} is obtained from pschymetric charts to correspond with 90 percent exhaust relative humidity and total heat per kg of dry air H_{ce} determined according to the system of

control recommended in a manufacturer's instructions and followed during the test, that is,

a) when a constant heat input is used

$$H_{ce} = H_{ca} + \left[\frac{D_t}{D_c} \times (H_{te} - H_{ta}) \right]$$

where

H_{ce} = exhaust total heat at specified conditions, kcals/kg dry air;

H_{te} = exhaust total heat during test, kg/kg dry air;

H_{ta} = ambient total heat during test, kg/kg dry air;

H_{ca} = ambient total heat at specified conditi ons, kcals/-kg dry air; that is,

with specified relative humidity 75 percent, 8·48 kcal/kg; and

with specified relative humidity 80 percent, 8·81 kcal/kg.

b) When constant relative humidity of ventilating air is recommended H_{ce} shall be obtained from hydrometric tables to correspond with the recommended relative humidity and the appropriate value of g_{ca} (0·008 1 kg/kg for 75 percent specified ambient relative humidity, 0·008 8 kg/kg for 80 percent specified ambient relative humidity) except that if the value of H_{ce} so obtained is incompatible with the lowest rate of heat supply of the installation, this value shall be ignored and a value substituted as calculated on the basis of **A-5** (*see* Note 2 for criterion of incompatibility).

c) When any other consistent system is used, the value of g_{ce} shall be determined from hydrometric tables to correspond with 90 percent relative humidity and total heat H_{ce} equal to that of the ventilating air at inlet to the grain except that if the value of H_{ce} so obtained is incompatible with the lowest rate of heat supply of the installation, this value shall be ignored and a value substituted as calculated on the basis of **A-5** (*see* Note 2 for criterion of incompatibility).

d) When the control system recommended specified use of the above systems for part of the time and the use of air unheated except by the fan motor and drive losses for the remainder of the time, the mean value of E_c for the whole period of the test shall be determined by calculating E_c as above for the portion of the total time

during which heat is applied, and calculating it for the remainder of the time by determining g_{ce} to correspond with 90 percent relative humidity and a total heat H_{ce} calculated as shown in **A-5**, Note 2.

A-2. Air supplied is given by the formula:

$$A_c = A_t \frac{Q_c D_c}{Q_t D_t}$$

where

A_c = corrected total air supplied, kg;

A_t = total air supplied on test of typical silo, kg;

Q_c and Q_t as under **A-1**, h;

D_t = density of air at fan on test, kg/m³; and

D_c = density of air at fan corresponding to specified ambient conditions, kg/m³.

A-3. Static pressure is given by the formula:

$$S_c = S_t \times \frac{D_c}{D_t}$$

where

S_c = corrected static pressure, kPa; and

S_t = static pressure on test, kPa.

A-4. Power consumption is given by :

Corrected total power consumption = $Q_c P_c$ (in appropriate units for example, kWh)

where $P_c = P_t \times \frac{D_c}{D_t}$

and $P_t = \frac{\text{Total consumption, on test, attributable to typical silo}}{Q_t}$

A-5. Fuel Consumption by Heaters is given by:

Corrected total fuel consumption = $Q_c F_c$ (in appropriate units, for example kWh)

where F_c is calculated as follows:

a) If a constant heat input rate is used:

$$F_c = F_t$$

where

$$F_t = \frac{\text{Total fuel consumption, on test, attributable to typical}}{Q_t}$$

b) If constant relative humidity of ventilating air, or any other consistent system is used:

$$F_c = \phi - P_c \eta m$$

where

$$\phi = \phi_t \times \frac{H_{ce} - H_{ca}}{H_{te} - H_{ta}} \times \frac{D_c}{D_t} \text{ ; and}$$

$$\phi_t = F_t + P_t \eta m$$

nm = thermal efficiency of fan, motor and drive. If the fan drive is so arranged that air taken into the installation at a point after the measuring point for ambient conditions is warmed by the motor and drive losses, *nm* has the value 1·00. Otherwise the efficiency of motor and drive shall preferably be measured under a load similar to that imposed by the fan under mean test conditions. If it is impractical to measure the efficiency a value *nm* = 0·85 shall be assumed where the fan is directly coupled to the motor, or 0·70 where there is a belt drive.

NOTE 1 — If $F_c >$ heater rating, a prominent foot-note should be appended to Table 1 calling attention to the fact and corrected values of heater consumption and drying time, and specific evaporation and specific heat consumption should be given in parentheses.

NOTE 2 — If $F_c < 0$ (that is, if $P_c \eta m > \phi_c$) the value of H_{ce} determined in **A-1**(b) and (c) and any derived values should be discarded and a value of H_{ce} should be determined as follows and used to calculate E_c and Q_c

$$H_{ce}\,(\,Min\,) = H_{ca} + \frac{3\,412\,P_t\,\eta m Q_t}{A_t}$$

where P_t is expressed in kW.

When H_{ce} and consequently $E_c Q_c$ have been calculated in this manner, the corrected results refer to a condition in which part of the grain in the silo is dried to a moisture content in equilibrium with air at a lower relative humidity than that recommended and the rest of the grain is at a higher moisture content. A foot-note should be appended to Table 1 calling attention to this fact.

c) If the control system recommended specifies the use of one of above systems for part of the time, and the use of unheated air for the remainder, the mean value of F_c for the whole period of the test shall be determined by calculating F_c as above for an appropriate proportion of the total time and taking F_c = 0°C for the remainder of the time.

APPENDIX B

(*Clause* 10.1)

IN-SILO DRYERS CALCULATION AS REFERRED TO IN TABLE 2

B-1. NUMBER OF SILOS VENTILATED

B-1.1 n_1 shall be the greatest number of silos which the manufacturer's instructions recommend ventilating at any one time.

n_2 shall be $\frac{n_1}{2}$ or $\frac{n_1 + 1}{2}$ if n_1 is an odd number. If the installation has only one silo capable of being ventilated or recommended for ventilation at any one time, so that $\frac{n_1 + 1}{2} = 1$, the lower section of the table shall be omitted.

B-2. INITIAL MASS OF BATCH (AT 20 PERCENT MOISTURE CONTENT)

$$\text{Initial mass of batch} = nW_t \times \frac{100 - P_t}{80}$$

where

n = number of silos ventilated (n_1 or n_2);

W_t = mass of wet grain in a single silo on test; and

P_t = mean moisture content of wet grain on test, percent.

B-3. RATE OF AIR SUPPLY (REQUIRED TO CALCULATE DRYING TIME AND ENERGY)

B-3.1 To determine the rate of air supply to n silos, the characteristics of fan power and duct static pressure shall be plotted against air quantity delivered, corrected to specified ambient conditions and curves of approximate system resistance obtained as described below superimposed on the pressure mass flow curve to obtain the total quantity delivered to n_1 and n_2 silos shown by the intersections of the fan characteristics and resistance curves:

$$S_c = S_t \times \frac{D_c}{D_t} \text{ kPa}$$

$$P_c = P_t \times \frac{D_c}{D_t} \text{ kW}$$

B-3.2 The approximate system resistance curves for n_1 and n_2 silos shall be determined by marking off on a line corresponding to a constant duct static pressure equal to the corrected duct static pressure S_c shown in Table 1, the total air flow for n_1 and n_2 silos, that is $n_1 \times$ corrected mean flow to test silo and $n_2 \times$ corrected mean flow to test silo. Through these two points curves shall be constructed to the equation $S = kQ^{1 \cdot 4}$ to intersect the fan pressure characteristic at flows Q_1 and Q_2 corresponding to n_1 and n_2 respectively.

where

S = duct static pressure,

k = constant, and

Q = mass flow rate, kg/h.

B-3.3 Power requirements P_1 and P_2 shall be read from the fan power characteristic to correspond to flow rates Q_1 and Q_2 respectively.

B-4. ENERGY FOR DRIVING FAN

B-4.1 Total energy for driving fan = $Q_x P_x$ kWh where P_x (kW) has the value P_1 or P_2 read from the fan power characteristic to correspond with flow rates Q_1 and Q_2 respectively.

B-5. DRYING TIME TO FINAL MOISTURE CONTENT

$$Q_x = \frac{nW_t (20 - q_x) (100 - P_t) A_c}{80 (100 - q_x) Q_x Q_c E_x}$$

where

n = number of silo ventilated;

W_t = mass of wet grain in a simple silo on test;

P_t = mean moisture content of wet grain on test, percent;

q_x = corresponding final moisture content (14, 15, 16 and 17 percent);

c_x = drying time, h;

Q_x = mass air flow Q_1 or Q_2 as above, kg/ h;

A_c = corrected total air supplied from Table 1, h;

Q_c = corresponding evaporation rate, kg/h; and

E_x = corresponding evaporation rate, kg/ h.

E_x shall be calculated as E_c (*see* **A-1** and **A-5**) except that the values of H_{ce} shall be determined to correspond with the appropriate value of g_{ca} and the following constant relative humidities (with the

exception noted below):

For 14 percent final moisture content, 63 percent relative humidity;

For 15 percent final moisture content, 71 percent relative humidity;

For 16 percent final moisture content, 77 percent relative humidity; and

For 17 percent final moisture content, with both 80 percent and 75 percent specified ambient relative humidity and for 16 percent final moisture content with 75 percent ambient relative humidity, and otherwise as noted in **B-6** the value of H_{ce} used to calculate E_x shall be:

$$H_{ce}\ (\ Min\ ) = H_{ca} + \frac{3\,412\ P_x m}{Q_x}$$

where P_x is expressed in kW.

NOTE — When H_{ce} and consequently E_x and Q_x have been calculated in this manner, the corrected results refer to a condition in which part of the grain in the silo is dried to a moisture content in equilibrium with air at a lower relative humidity than that recommended and the rest of the grain is at a higher moisture content. A foot-note should be appended to Table 2 calling attention to this fact.

B-6. ENERGY FOR HEATERS

B-6.1 Total energy for air heaters = $Q_x\ F_x$ (in appropriate unit, for example kWh)

where $F_x = \phi_x - P_x \eta m$ (in appropriate units, for example kW)

$$\phi_x = \phi_t \times \frac{H_{ce} - H_{ca}}{H_{te} - H_{ta}} \times \frac{D_c}{D_t} \times Q_t \frac{Q_c}{A_c}$$

$$\phi_t = F_t + P_t \eta m$$

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